I. Questions: 6 points

Q1. A ______________ wave is the stationary, wavelike pattern that results from the interference of two or more traveling waves.

Q2. Standing waves have regions of minimum amplitude called nodes/antinodes and regions of maximum amplitude called nodes/antinodes.

Q3. The _______________ of a “number” is the power to which the base (usually 10) must be raised in order to give the “number.”

Q4. Logarithms are useful in the study of sound because _______________ scales (e.g., equal temperament) and _______________ levels (e.g., decibels) cover wide ranges of values.

Q5. The physical parameter most directly connected with loudness is sound _______________.

Q6. The _______________ scale is a logarithmic scale used for comparing sound levels.

II. Problems: 19 points

P1. An open organ pipe (both ends open), 16 feet long, is operating in air at 20°C. The fundamental frequency $f_1 =$ __________ Hz and the second harmonic frequency $=$ __________ Hz.

P2. Suppose the air is replaced by helium at 20°C ($v = 1005$ m/s). For an open pipe (both ends open), 16-ft in length, the new fundamental frequency $f_1 =$ __________ Hz.

P3. In order to produce a fundamental frequency of 10 Hz in a stopped organ pipe (one end closed), the required length $L =$ __________ m.

P4. The trombone behaves like a pipe that is open at both ends. The lowest note that can be played on a 10-ft-long trombone $=$ __________ Hz.

P5. Two identical organ pipes, both at 20°C, have frequencies of 500 Hz. If the temperature of one pipe is raised to 33°C, its new frequency $=$ __________ Hz.

P6. One model of the outer ear canal is a cylindrical pipe 3.0 cm long that is closed at one end by the eardrum. The resonant (fundamental) frequency for this closed pipe is $=$ __________ Hz.

P7. Find the following logarithms:

$$\log 2 = \text{__________}, \log 4 = \text{__________}, \log 200 = \text{__________}.$$
P8. Given \( \log x \), find the number \( x \):

\[
\log x = 0.3, \quad x = \underline{\text{__________}}; \quad \log x = 3.00, \quad x = \underline{\text{__________}}.
\]

P9. A sound of intensity \( I = 2.0 \times 10^{-6} \text{ W/m}^2 \) falls on a detector of area \( A = 7 \times 10^{-5} \text{ m}^2 \). (Note: this is about the size of an eardrum.) The total power \( P \) being received by this detector = \( \underline{\text{__________}} \text{ W} \).

P10. For a sound of intensity \( I = 2.0 \times 10^{-6} \text{ W/m}^2 \), the sound level (in decibels) = \( \underline{\text{__________}} \text{ dB} \).

P11. Given a sound with \( L_p = 50 \text{ dB} \), the sound pressure = \( \underline{\text{__________}} \text{ N/m}^2 \) and the sound intensity = \( \underline{\text{__________}} \text{ W/m}^2 \).

P12. If two sounds differ in level by \( 46 \text{ dB} \), the ratio of their intensities = \( \underline{\text{__________}} \).

P13. Two sound sources produce sound power levels of \( 53 \text{ dB} \) and \( 66 \text{ dB} \). Relative to the reference power level \( W_0 = 10^{-12} \text{ W} \), this gives \( W_1/W_0 = \underline{\text{__________}} \), \( W_2/W_0 = \underline{\text{__________}} \), and a sound power ratio \( W_2/W_1 = \underline{\text{__________}} \).

P14. At a rock concert, a dB meter registers \( 125 \text{ dB} \) when placed \( 3.0 \text{ m} \) in front of a loudspeaker on the stage. [You may assume uniform spherical spreading of the sound from the speaker.]

The intensity of the sound at the location of the dB meter = \( \underline{\text{__________}} \text{ W/m}^2 \).

P15. At a rock concert, a dB meter registers \( 125 \text{ dB} \) when placed \( 3.0 \text{ m} \) in front of a loudspeaker on the stage. [You may assume uniform spherical spreading of the sound from the speaker.]

The sound power output of the speaker = \( \underline{\text{__________}} \text{ W} \).

P16. For a sound wave at the threshold of pain \( (L_p = 120 \text{ dB}) \), the sound pressure = \( \underline{\text{__________}} \text{ N/m}^2 \) and the force on an eardrum with a diameter of \( 8.0 \text{ mm} \) = \( \underline{\text{__________}} \text{ N} \).

P17. A trombone bell has an area of \( 0.10 \text{ m}^2 \). If the power radiated from the bell during a very loud note is \( 1.5 \text{ W} \), the sound intensity = \( \underline{\text{__________}} \text{ W/m}^2 \) and the sound intensity level = \( \underline{\text{__________}} \text{ dB} \).

P18. For a speaker whose sound power output is \( 140 \text{ dB} \), the distance from the speaker at which the sound level will be reduced to \( 90 \text{ dB} \) is \( \underline{\text{__________}} \text{ m} \).

P19. If the sound from a \( 1.0 \text{ W} \) speaker radiates equally in all directions, at a distance of \( 4.0 \text{ m} \) the sound intensity (level) is _____ times (or _____ dB less than) the values at a distance of \( 2.0 \text{ m} \).